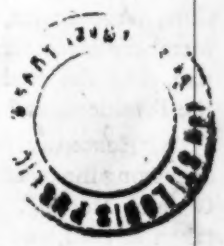

TRANSACTIONS

OF THE

ILLUMINATING ENGINEERING SOCIETY

FOUNDED IN LONDON 1909 INCORPORATED 1930

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VOLUME III—No. 6
JUNE, 1938

32 VICTORIA STREET
LONDON SW1

PROCEEDINGS AT THE ANNUAL GENERAL MEETING

The Annual General Meeting of the Illuminating Engineering Society was held in the Lecture Theatre of the Institution of Mechanical Engineers (Storey's Gate, Westminster, S.W.1) on Tuesday, May 10, 1938. Members assembled for light refreshments at 6.30 p.m., and the chair was taken by Dr. S. ENGLISH, the President, at 7 p.m.

The HONORARY SECRETARY having read the notice convening the meeting, the minutes of the last Annual General Meeting, which had been published, were taken as read, and confirmed.

THE PRESIDENT, in presenting the report of the Council for the past session, which had been circulated to all members of the Society, drew attention to the list of officers and members of Council mentioned in the initial paragraphs of the report who, in the absence of other nominations, were automatically elected. In doing so he referred to the death, on March 25, of Mr. J. R. Hepple, an old and valued member of the Society, who had been elected to serve on the Council. The vacancy thus caused would be filled by the Council when it met in the next session.

Continuing, the President referred to the important work done by the four sections in London, and also expressed appreciation of the sterling work done by the chairmen and secretaries of the committees of the various Technical Sections.

The next outstanding feature of the report, he said, was the work of the Local Sections in Glasgow, Dublin, Leeds, and Manchester. He specially mentioned the fact that Leeds, the youngest of the four, already had a membership of about 100. A fifth section was in process of being formed in Birmingham, where Mr. Howard Long would be chairman and Mr. A. E. B. Wallis would be honorary secretary. These two gentlemen were preparing a programme for next session, which showed every signs of being extremely satisfactory.

Another matter, upon which he had also laid stress in his Presidential Address, was that the *Transactions* had appeared regularly, and included all the papers before the main Society, and one or two which had been given to the Sections. The fear which some people had that the publication of the *Transactions* would involve a heavy financial drain on the Society had not, fortunately, materialised. Indeed, the *Transactions* had been issued without any serious drain on its finances, a result upon which the editor deserved congratulation from the Society.

Reference was next made to the scheme of examinations in Illuminating Engineering, and thanks were recorded to Mr. A. A. Cunnington for his work on the Joint Committee formed by the City and Guilds of London Institute to deal with this matter. The syllabus which had been issued followed very closely on the lines which the Council of the Society desired.

Finally the President referred to the membership, which last year had increased rapidly to 800 after relatively gradual progress during several years, a state of affairs which was largely due to the formation of the Technical Sections and Local Centres. The Council was looking forward to the membership reaching the 1,000 mark in the very near future.

Mr. E. STROUD (Honorary Treasurer), after reading the auditors' statement, presented the accounts, and pointed out that there was a surplus of £118 as compared with only £32 in the previous year. There had been an increase of £82 in subscriptions received. Altogether, he said, the accounts could be regarded as very satisfactory.

Mr. A. E. ILIFFE, moving the adoption of the report and accounts, said the members were grateful for all the work that had been done by the President and Council and also the honorary officers, especially Mr. Dow, the Honorary Secretary. Speaking of the Local Centres, he said that those in the provinces were very grateful to the President for his personal attendance at many of their meetings, which had been a great encouragement to them.

He moved: "That the report of the Council for the Session 1937-38 and the accounts for the period from January 1, 1937, to December 31, 1937, be hereby adopted, and that a vote of thanks be extended to the President, Council and officers for their efforts on behalf of the Society during the past session."

Mr. K. F. SAWYER seconded the motion.

THE PRESIDENT, before putting the resolution to the meeting, thanked the proposer and seconder of the motion for their cordial remarks regarding the work of the Council. He then called for any questions upon the reports and accounts, but, as none were asked, he put the resolution to the meeting.

The motion for the adoption of the report and accounts was then carried unanimously.

Mr. E. H. PENWARDEN moved: "That this meeting records its appreciation of the services of Messrs. Robert J. Ward and Co. as auditors of the Society, and approve of their re-election for the next session."

Mr. VICTOR F. BEUTTELL seconded, and the motion was carried unanimously.

This closed the business of the Annual General Meeting.

Illuminating Engineering Society
(Founded in London, 1909; Incorporated 1930)
32, VICTORIA STREET, LONDON, S.W.

REPORT OF THE COUNCIL FOR THE SESSION OCTOBER, 1937, TO MAY, 1938.

(Presented at the Annual Meeting held on Tuesday, May 10th, 1938.)

During the past session there has again been substantial progress in many directions.

Election of Officers and Council for next Session.

In accordance with the procedure outlined in the Articles and By-laws of the Society, the nominations made by the Council to fill vacancies have been printed in the "Transactions" of the Society, and corporate members have thus been afforded an opportunity of making additional nominations, if they so desired. No nominations having been received the proposals of the Council stand.

Accordingly, Mr. Percy Good will become president for the next session. Colonel C. H. Silvester Evans will become vice-president, Mr. J. S. Dow will continue to act as honorary secretary, and Mr. E. Stroud will continue to act as honorary treasurer.

The following members will fill vacancies on the Council: Mr. T. C. Angus, Mr. H. Buckley, Mr. W. N. C. Clinch, Mr. L. J. Davies, Mr. A. V. Horsfall, and Major P. A. Smith.

The Council record with regret that Mr. J. R. Hepple, who had consented to accept nomination on the Council, passed away on March 25.

Work of Committees.

The following standing committees have been appointed during the past session:—

General Purposes Committee.—Dr. S. English (president and chairman), Mr. J. S. Dow (honorary secretary), Mr. E. Stroud (honorary treasurer), Mr. A. W. Beuttell, Mr. A. Cunnington, Mr. F. C. Smith, and Mr. H. Hepworth Thompson.

Papers Committee.—Mr. G. H. Wilson (chairman), Mr. Dean Chandler, Dr. W. M. Hampton, Mr. W. J. Jones, Mr. A. R. McGibbon, Mr. J. S. Preston, and Dr. J. W. T. Walsh.

Technical Committee.—Mr. J. S. Preston (chairman), Mr. A. W. Beuttell, Mr. H. Bright, Mr. W. J. Jones, Mr. H. Lingard, Professor J. T. MacGregor-Morris, Mr. A. R. McGibbon, Mr. C. A. Masterman, Mr. F. C. Smith, Mr. E. Stroud, Mr. L. M. Tye. Co-opted: Mr. H. Buckley, Mr. Victor F. Beuttell (secretary).

Development Committee.—Mr. R. O. Ackerley (chairman), Mr. A. W. Beuttell, Mr. B. F. W Besemer, Mr. J. F. Colquhoun, Mr. A. Cunnington, Mr. A. R. McGibbon, Mr. E. W. Murray, Mr. F. C. Smith, Mr. J. M. Waldram, Mr. H. C. Weston. Co-opted: Mr. T. E. Catten, Mr. F. P. Bentham, Mr. S. J. Patmore (secretary).

The *ad hoc* committee appointed in the previous session to consider the question of examinations in illuminating engineering has concluded its work. The composition of this committee is as follows:—

Lighting Education and Examinations Committee.—Mr. A. Cunnington, Mr. J. G. Clark, Mr. J. S. Dow, Dr. S. English, Mr. H. Lingard, Mr. F. C. Smith, and Dr. J. W. T. Walsh.

The General Purposes Committee has had before it several questions of outstanding importance. It has been engaged on the preparation of rules for the guidance of the Council in regard to the nomination of committees, and has already devoted some consideration to a matter that may call for action in the near future—the determination of the conditions to be observed by local centres that desire to obtain formal status as a recognised branch of the Society.

It has also been considering the proposal that some form of annual conference, such as would afford an opportunity for the members of the various local centres and the members from London to meet together at least once in the year, should be inaugurated.

The technical committee has completed several phases of its work mentioned in the last annual report. The "Recommendations concerning the Use of Portable Photometers" and the revised version of the "Recommended Values of Illumination" have appeared in the "Transactions" and have since been reprinted in pamphlet form. Some further revisions of the latter, for inclusion in the next edition, are

now being considered. The other chief task of the committee has been the preparation of "Recommendations on the Lighting of Cinema Auditoriums," undertaken at the request of the London County Council, which have recently been completed and await publication.

The Development Committee has been mainly concerned with the development of the various special sections of the society, the activities of which are summarised below. Encouraged by the success of the four existing sections the committee has recommended the inauguration of a fifth, to deal with commercial lighting (the lighting of shops, offices, and banks, illuminated signs, floodlighting, etc.). The Council has approved the formation of this new section which should commence operations with the opening of the new session in October next.

The special *ad hoc* committee, concerned with lighting education and examinations, has been actively concerned with the preparation of data for the joint committee formed by the City and Guilds Institute in order to prepare a syllabus for examinations in illuminating engineering, to which reference is made below.

The Leon Gaster Memorial Fund.

A statement of the income and expenditure of this fund, which is now in its seventh year of operation, is appended. The seventh award of the Leon Gaster Premium of ten guineas was made during the past session to Mr. G. T. Winch and Mr. L. C. Jesty for their joint paper entitled "Television Images: An Analysis of their Essential Qualities," read at the meeting of the Illuminating Engineering Society on April 13, 1937.

No applications for the Silver Jubilee (1934) Commemoration Award were received during the past session.

General Meetings.

At the opening meeting on October 12, 1937, the presidential address was delivered by Dr. S. English, who dealt mainly with research in the lighting industry and with the education and training of the illuminating engineer. Dr. English concluded by suggesting the desirability of an annual illumination convention or congress, such as would serve as a reunion for members of the society and delegates from other bodies.

The address was followed by a representative display of apparatus illustrating progress in illumination and photometry, which once again proved to be a most successful and popular event.

On November 15, at a joint meeting with the Association of Supervising Electrical Engineers, a paper on "Lighting for Special Industrial Purposes" was read by Mr. S. Anderson and Mr. W. R. Stevens. Subsequent papers, on December 14 and January 11, were devoted to "Incandescence Gas Lighting" (Mr. Dean Chandler), "Decorative Materials and their Response to Light" (Mr. R. O. Ackerley). On February 8. Dr J. W. T. Walsh opened a discussion on the final report of the Ministry of Transport Committee on street lighting. The discussion was followed by the display of a special film, presented by Mr. C. Dunbar, of the National Physical Laboratory, illustrating a new method of testing the visibility by various qualities of light, of small objects exhibited with the road surface and footpath as background.

Another joint meeting, on this occasion with the Institution of Heating and Ventilating Engineers, took place on March 1, when a paper by Mr. F. C. Smith, entitled "Illumination Levels and Comfort Conditions," was read. In this paper the problems involved in lighting, heating, and ventilation were surveyed in turn, and the necessity for co-ordination of effort on the part of the illuminating engineer and the heating and ventilation engineer was emphasised.

The concluding paper of the Session was read by Mr. J. W. Ryde on April 12, and dealt with "Luminescent Materials and their Application to Light Sources." This paper was illustrated by numerous interesting demonstrations and exhibits.

Following the transaction of formal business at the annual meeting on May 10, the Society will revert to its practice of arranging for an address by some expert on illumination from abroad, the speaker on this occasion being Mr. E. Uytborck, who will review progress in illumination in Belgium.

Sectional Meetings.

A feature of the past session has been the success of the series of meetings organised by the four existing Special Sections of the Society. In spite of the fact that the number of meetings held in London is about four times as many as was usual a few years ago, good audiences have been almost invariably obtained. It is somewhat remarkable that on certain occasions sectional meetings have drawn attendances quite as great as those usual at general meetings, and even greater. Whilst there are a certain number of members who make a practice of attending practically all meetings held in London, it would appear that in general each section attracts its own nucleus of members, as well as visitors peculiarly interested in the range of topics discussed. The Sections thus appear to be fulfilling their purpose in catering for the needs of those interested mainly in special aspects of lighting, such as can only be occasionally dealt with at general meetings, and of extending the sphere of influence of the Society in new directions.

Photometry Section.

Organising Committee.—Mr. G. T. Winch (chairman), Mr. M. G. Bennett, Mr. H. Buckley, Professor J. T. MacGregor Morris, Mr. F. C. Smith, Mr. E. Stroud, Mr. J. M. Waldram, Dr. J. W. T. Walsh, and Mr. Kenneth F. Sawyer (honorary secretary).

Three meetings have been held. On November 23 a paper on "The Photometry of Projectors" was delivered by Dr. W. M. Hampton, and led to a keen discussion. In accordance with the request of the

Committee, arrangements have been made for the publication of his paper and the ensuing discussion in the *Transactions*.

On January 18 a visit took place to the Paint and Varnish Research Laboratory at Teddington, when a paper entitled "The Application of Photometric Methods in the Testing of Paint and Allied Products" was read by Dr. Hanstock.

On April 5 a paper dealing with "Telephotometry" was read by Mr. L. J. Collier.

Industrial Lighting Section.

Organising Committee.—Mr. R. O. Ackerley (chairman), Mr. P. S Barton, Mr. W. J. Edwards, Mr. A. R. McGibbon, Mr. E. W. Murray, Mr. H. C. Weston, Mr. H. N. Winbolt, and Mr. C. W. M. Phillips (honorary secretary).

This section, now completing its second session, continues to make excellent progress. Six meetings have been arranged devoted respectively to "The Economics of Factory Lighting," by Mr. A. E. Iliffe (October 19, 1937); a paper on "Lighting for Special Industrial Purposes," by Mr. S. Anderson and Mr. W. R. Stevens, which ranked also as a general meeting (November 16, 1937); a Visit to the Printing Works of Messrs. Waterlow and Sons, Ltd., where the installation was described by Mr. L. M. Tye (December 7); a paper on "Railway Lighting," by Mr. M. G. Bennett, serving as a joint meeting with the Public Lighting Section (January 28); a Discussion on Various Problems in Industrial Lighting, to which Mr. A. S. M. Brackenbury, Mr. W. J. Edwards, and Mr. H. N. Winbolt contributed (February 22); and a Discussion on the New Factory Act in Relation to Industrial Lighting (March 29).

The latter was, perhaps, the most successful of the series of meetings, the lecture theatre at the Home Office Industrial Museum being completely filled by an audience which listened with keen interest to the diverse expressions of view of Mr. H. N. Winbolt, Mr. E. W. Murray, Mr. D. Gluckstein, and Dr. S. English.

Public Lighting Section.

Organising Committee.—Mr. F. C. Smith (chairman), Mr. A. W. Beuttell, Mr. E. J. Elford, Dr. H. F. Gillbe, Mr. A. S. Tapsfield, Mr. J. M. Waldram, and Mr. K. N. Hatton (honorary secretary).

This section, formed at the end of the previous session, has completed its first series of meetings. The opening meeting, held on October 29, 1937, at the Research Laboratories of the General Electric Company, Ltd., Wembley, which were thrown open for inspection, was devoted mainly to an inaugural address delivered by Dr. C. C. Paterson. On January 28 the joint meeting with the Industrial Lighting Section mentioned above, at which Mr. M. G. Bennett read his paper on Railway Lighting, took place. On February 18 there was a paper by Mr. E. J. Elford on "The Relighting of a Borough," which was preceded by an inspection of street lighting installations in Wandsworth. The final meeting, on March 4, was devoted to a discussion of technical aspects of the final report of the M.O.T. Street Lighting Committee, which was opened by Mr. G. S Lucas and Mr. A. R. McGibbon.

At all the above meetings there were good attendances and keen discussions.

Decorative Lighting Section.

Organising Committee.—Mr. A. W. Beuttell (chairman) Mr. R. O. Ackerley, Mr. J. M. Barnicot, Mr. F. P. Bentham, Miss K. M. Halpin, Mr. G. Lovell, Mr. Waldo Maitland, Miss V. Norvick, Mr. E. H. Penwarden, Mr. A. R. Read, Mr. R. O. Sutherland, and Mr. D. W. Durrant (honorary secretary).

This newly formed section has had a very active session, comprising six meetings and one visit. The opening meeting (November 9, 1937), when Monsieur J. Dourgnon and Mr. R. O. Sutherland contributed illustrated descriptions of the lighting of the International Exhibition in Paris, drew one of the largest audiences of the session. The subsequent meeting, held on December 10, 1937, in the R.I.B.A. building, was devoted to three addresses by eminent architects (Mr. Oliver P. Bernard, Mr. Lawrence M. Gotch, and Mr. Albert D. Millar). Subsequent events comprised a visit to the store of Messrs. D. H. Evans (January 27), a paper by Mr. E. H. Penwarden on "The Relation between Artistic Design and the Mechanical Construction of Fittings" (February 15), a paper by Miss Edna Moseley entitled "How I would plan the Lighting of a Home" (March 22), and a discussion on Glassware in Relation to Decorative Lighting, opened by Mr. Oliver Bernard and Dr. W. M. Hampton (April 29).

Considering the volume of work accomplished the sections have been administered very efficiently and economically, being therein greatly aided by hospitality received in connection with the holding of meetings at the following centres: The Council offices, Borough of Wandsworth; Messrs. D. H. Evans's store; the E.L.M.A. Lighting Service Bureau; Gas Industry House; the G.E.C. Research Laboratories; the Holophane Lecture Theatre; the Home Office Industrial Museum; Magnet House; the Paint and Varnish Research Laboratory; Messrs. Waterlow and Sons' factory; Watson House; and the Westminster Technical Institute.

Besides meeting the needs of existing members the various sections have attracted an encouraging influx of visitors, quite a number of whom will, it is hoped, ultimately become members of the Society. As an instance it may be mentioned that although the Industrial Lighting Section has only been in existence for two years, twenty-five members of the Society who first came in contact with it as visitors to meetings of this section, have been noted.

As mentioned previously, the favourable experience of these four existing sections has encouraged the Council to approve the formation of a fifth one,

to deal with Commercial Lighting, which it is hoped to bring into operation next session.

Meetings of Local Centres.

The growth of the Society has again been well illustrated by the activities of its local centres, of which there are now four.

The programme arranged by Mr. J. Sellars, the honorary secretary of the North-Western Area, included a visit to Chester to inspect the illuminations, an address on Progress by Mr. A. Cunnington, followed by a display of apparatus lighting and addresses on such topics as Gas Lighting (Mr. H. E. Chancellor), the Measurement of Daylight in Buildings (Mr. J. Swarbrick), Lighting for Sports and Entertainments (Mr. A. Edgar), Factory Lighting (Mr. W. A. Thurley), and Colliery Lighting (Mr. J. W. Howell).

The programme for the Scottish Centre in Glasgow, where Mr. M. W. Hime is acting as honorary secretary, also included an exhibition of lighting fittings and an opening address by the president (Dr. S. English) on New Aspects of Street Lighting. Subsequent meetings were devoted to Electric Lamps: their Specification and Testing (Mr. T. M. Lappin), Street Lighting (Mr. W. J. A. Davey), the Automatic Control of Lighting (Mr. H. E. de Weerdt), and a discussion on industrial lighting.

In Dublin the programme arranged by Mr. J. Creagh opened with a paper on Fundamentals in Lighting by Mr. E. J. Davidson. Subsequent meetings were devoted to Home Lighting (Mr. J. Creagh), Glassware in relation to Illuminating Engineering (Dr. S. English), the Sodium Electric Discharge Lamps (Professor G. B. Van der Werfhorst), Lighting from the Architect's Point of View (Mr. F. J. Ryan), and Modern Colour Lighting (Mr. R. Gillespie Williams).

The most recently formed centre for the North Midland Area, with headquarters in Leeds, has made excellent progress during its first session, mainly owing to the enterprise of a strong and representative local committee and the efforts of its honorary secretary (Mr. J. W. Howell).

An early start was made by a visit to Kirkstall Power Station on September 20, when there was also an address on Progress by Mr. A. W. Beuttell and a display of lighting equipment. Subsequent items included papers on Street Lighting (Mr. J. F. Colquhoun), Floodlighting (Mr. D. G. Wolfenden), Decorative and Colour Lighting (Mr. R. Gillespie Williams), Lighting in the Textile Industry (Mr. J. W. Howell) Fluorescence and Luminescence (Mr. H. G. Jenkins).

An enterprising departure was the annual dinner —the first arranged by a local centre—on March 21, presided over by the chairman (Councillor Sellers), which was attended by the president (Dr. S. English) and the honorary secretary (Mr. J. S. Dow), from London, and by the chairman (Mr. R. J. Hawkins) and the honorary secretary (Mr. J. Sellars), of the North-Western Area Local Centre.

It will be observed that on several occasions addresses have been given before local centres by members from London, and that it may be mentioned that the president visited in turn each of the four local centres. It is hoped that such visits will become customary and that members resident in London will take every possible opportunity of attending meetings in other cities. The Council is most anxious that members resident in different areas should have better opportunities of meeting each other and discussing topics of common interest, such as might be provided by an annual reunion of the type which is now being considered.

Growth in the membership of local centres, and in particular that of the North Midland Centre, which, after little more than a year's experience, is already approaching the 100 mark, has recently brought into prominence the question of giving formal recognition of the existing local centres, at present on an informal basis, where desired, and the necessary conditions are being explored.

A fifth local centre for the Midland area has now come into being. The project was discussed at a special meeting in Birmingham, which was attended by several members of Council from London, on April 8, when a resolution approving the formation of the centre was passed unanimously. An organising committee, with Mr. Howard Long as chairman and Mr. A. E. B. Wallis as honorary secretary, was elected and will prepare a programme of events for the forthcoming session.

The Visit to Paris.

A party of members of the Society, about two dozen in number, visited Paris during September 17 to 21, 1937. The party, which included the presidents for 1936-37 and 1937-38 (Mr. A. Cunnington and Dr. S. English) and the honorary secretary, had an excellent opportunity of studying the chief features of the decorative lighting at the Exhibition, which subsequently formed the subject of addresses before the Decorative Lighting Section of the Society.

The thanks of the Society are due to MM. Maisonneuve and Chappat of the Compagnie des Lampes, and to M. Maurice Leblanc, the President of the Association des Ingénieurs de l'Eclairage, who went to considerable trouble to ensure that the party saw the utmost possible during the short period of their visit.

The Annual Dinner.

The Annual Dinner took place at the Trocadero Restaurant on March 15, when there was a good attendance—the number present having been exceeded on only one similar occasion in the past. The toast of "The Illuminating Engineering Society" was proposed by Sir Alexander Maxwell (Permanent Under Secretary, Home Office), who referred specially to the importance of good industrial lighting, now recognised by the inclusion for the first time of a requirement of adequate and suitable lighting in the Factory Act. The President (Dr. S. English) responded. The toast of "The Guests" was proposed by Mr. Percy Good (Vice-President) and responded to by Sir David Munro (Secretary of the Industrial Health Research Board). As usual there was a representative assembly of guests. The re-

mainder of the evening was devoted to dancing and social intercourse.

Issue of "Transactions."

The publication of papers and discussions read before the Society in the form of *Transactions* has now been in operation for two sessions. It is satisfactory to observe that the net expenditure involved has not proved too onerous, and has, indeed, diminished somewhat during the past session. In addition to the publication of all papers read at general meetings, several other contributions have been included in the *Transactions* by request, namely, Mr. Guild's address on "Colorimetry and its Relation to Photometry," Dr. Hampton's paper on "The Photometry of Projectors," both presented before the Photometry Section, and an independent contribution by Mr. G. T. Winch and Miss Evelyn Palmer entitled "A Direct Reading Photoelectric Trichromatic Colorimeter." The Council attaches great importance to the inclusion in the *Transactions* of original and valuable matter. It is recognised that the material of this nature presented at Sectional Meetings and before Local Centres will doubtless tend to increase, and that room should also be found for reports of a technical nature, such as the "Recommended Values of Illumination" and the "Recommendations Concerning the Use of Portable Photometers," recently reprinted in pamphlet form. In the meantime, information of a more general character and descriptive accounts of sectional and local meetings continue to appear in LIGHT AND LIGHTING.

The Library.

A considerable amount of work has been carried out in connection with the Library at 32, Victoria-street, under the direction of the Committee, and with the assistance of the honorary librarian, Mr. J. B. Score-Smyth. A number of new books has been acquired or presented, and the available works have been grouped and stamped with appropriate reference numbers. A special bookplate is now being prepared. It is hoped that the catalogue will be completed and the Library will be completely at the service of members in the course of next session.

Examinations in Illuminating Engineering.

The Joint Committee formed by the City and Guilds of London Institute, with the object of organising examinations in illuminating engineering, has been actively at work and has now completed and issued the scheme and syllabus for the Intermediate Grade and Final Grade Examinations. It is gratifying to observe that in substance they satisfy the desires expressed by the Illuminating Engineering Society. The Council would like to take this opportunity of expressing their appreciation of the services of their representative, Mr. A. Cunnington, on this Committee. They also record with pleasure the appointment, as the first examiner, of a member of the Society of very long standing, Professor J. T. MacGregor Morris.

The completion of this scheme of examinations marks a further stage in the development of illuminating engineering as a profession. Another step which the Council regard as of vital importance, the framing of conditions to be complied with by members who desire some form of qualifying status, and the adoption of some appropriate description for those who have met these requirements, is under consideration.

Membership.

Substantial additions to the membership of the Society have been received, with the result that the total membership of all classes now approaches 800—a gain of approximately 100 during the past year. It is hoped that the development of local centres and special sections will ultimately lead to considerable further increases, and that if every member will endeavour to interest others in the work of the Society, it should not be very long before the 1,000 mark is attained.

Financial Position.

The accounts for the past year, which are attached, again reveal progress. It is satisfactory to observe that the increase in income has more than sufficed to cover the expenditure involved in the Society's growing activities. The amount received in subscriptions is about £80 more than in the previous year and the net expenditure on the *Transactions* has materially diminished. On the other hand expenditure on meetings is naturally greater. It will be observed that expenditure on sectional and provincial meetings is now shown in the form of separate items. Such items must be expected to increase as new sections are formed and new local centres created, so that a corresponding increase in revenue from additional members is clearly necessary.

No change has occurred in the reserve funds of the Society, which remain invested in £1,500 of 3½ per cent. War Stock.

Relations With Other Bodies.

Members of the Society continue to take an active part in the work of other organisations interested in illumination. The Society appoints annually representatives to serve on the National Illumination Committee. A considerable number of its members serve on the various committees operating under the National Illumination Committee, the British Standards Institution, and the Department of Scientific and Industrial Research.

Members who have been serving on the Departmental Committee on Public Lighting, operating under the Ministry of Transport, have been released by the termination of the work of this Committee and the issue of its final report. A new opportunity for service has, however, presented itself in the Departmental Committee formed by the Home Office to deal with factory lighting, on which several members of the Society are serving and of which Sir Duncan Wilson, the Chief Inspector of Factories and a past president of the Society, is chairman. A deputation, for whom the president acted as spokesman, has

given evidence before the Committee in regard to the proposed modifications in the original recommendations on lighting in factories and workshops.

A problem in regard to the lighting of cinema auditoriums, which was referred to the Society by the London County Council in 1937, has now been dealt with by a panel appointed by the Technical Committee, whose report has been received by the Council.

On several occasions the Society has arranged joint meetings with other bodies. On November 16, 1937, the paper by Mr. S. Anderson and Mr. W. R. Stevens on "Lighting for Special Industrial Processes" was presented before a joint meeting with the Association of Supervising Electrical Engineers. On March 1, Mr. F. C. Smith's paper on "Illumination Levels and Comfort Conditions" was read at a joint meeting with the Institution of Heating and Ventilating Engineers. On October 8, 1937, the Society took part in a joint session with the National "Safety-First" Association, in connection with the annual conference of that body in London. A paper, entitled "Lighting for Speed and Safety," was read by Mr. A. Cunnington, and led to an excellent discussion in which a number of members of both bodies took part.

Programme for the Next Session.

The programme for the 1938-39 session is now in course of preparation. Offers of papers and suggestions in regard to meetings, visits, or other special events will be welcomed by the Honorary Secretary. Special importance is attached to contributions of an original character. It is particularly desired that the manuscripts of papers should be received in good time before the opening of the session in October next, so that ample time may be available to allot dates, and to take any measures necessary to ensure informative and successful meetings.

Entries for the Silver Jubilee Commemoration (1934) Award, which should be in the hands of the Honorary Secretary by June 30, will also be welcome.

In addition to the general programme of meetings in London, the attention of members is also drawn to the activities of the informal local centres and of the various Special Sections for which independent programmes are arranged.

As mentioned above, an additional Local Centre for the Midland Area and another Special Section to deal with the subject of commercial lighting are proposed, and it may be that still further extensions will become desirable as the influence of the Society extends. The success of such efforts depends largely on decentralisation of effort and on the co-operation of members as a whole, and the Council desires to take this opportunity of acknowledging the aid of those who are already acting on committees or undertaking secretarial duties. They would also welcome offers of service by others who are prepared to help in the considerable amount of administrative work which these new ventures involve.

S. ENGLISH
(*President*).
JOHN S. DOW
(*Hon. Secretary*).

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1937.

Dr. EXPENDITURE.

	£ s. d.	£ s. d.
To Administration Expenses:—		
Rent and Clerical Work, etc. ...	250 0 0	
Printing, Stationery, etc.	166 19 5	
Duplicating	65 18 8	
General Expenses	112 14 1	
Hire of Halls for Meetings	26 5 0	
Reporters and Lantern Operators ...	28 17 0	
Refreshments at Meetings	12 14 0	
Provincial Meetings Expenses ...	62 2 6	
Sectional Meetings Expenses	24 3 10	
Bank Charges	1 1 9	
Audit Fee	10 10 0	
		761 6 3
,, Informal Social Evening	46 12 1	
Less Receipts	35 5 0	
		11 7 1
,, Cost of Printing Transactions, Reprints, Blocks, etc.	244 14 10	
Less Sales of Reprints and Blocks ...	59 5 0	
		185 9 10
,, Illuminating Engineering Publishing Co., Ltd.—Share of Subscriptions		360 18 0
,, National Illumination Committee		32 0 0
,, British Standards Institution		10 10 0
,, Leon Gaster Memorial Fund		5 0 0
,, Premium on Deferred Annuity to Staff		38 15 3
,, Honorarium to Librarian		10 10 0
,, Excess Income over Expenditure		118 8 6
		£1,534 4 11

INCOME. *Cr.*

	£ s. d.	£ s. d.
By Subscriptions		1,420 0 0
(Including One Life Member—£15 15 0)		
,, Subscriptions Outstanding (Estimated)		20 0 0
,, Interest on War Stock		52 10 0
,, Deposit Interest		3 9 1
,, Sundries, Subscriptions on Transactions, etc. ...		14 5 9
,, Annual Dinner—		
Receipts	£212 0 0	
Less Payments	187 19 11	
		24 0 1
		£1,534 4 11

BALANCE SHEET, 31st DECEMBER, 1937.

LIABILITIES.	£ s. d.	£ s. d.
Creditors		64 7 10
Subscriptions paid in advance		39 3 0
Capital Account:—		
Balance from last Account	1,658 8 4	
Add Excess of Income over Expenditure for the year	118 8 6	
		1,776 16 10
		£1,880 7 8

ASSETS.	£ s. d.
Cash at Bank	259 6 1
Cash in hand	8 14 7
£1,500 3½ per cent. Registered War Stock at cost	1,559 15 0
Subscriptions Outstanding	20 0 0
Sundry Debtors on Sales Transactions	32 12 0
	£1,880 7 8

LEON GASTER MEMORIAL FUND ACCOUNT, 31st DECEMBER, 1937.

	£ s. d.	£ s. d.
Fund at the beginning of the year		242 18 4
War Stock Interest	8 1 0	
Transferred from General Fund Account	5 0 0	
		13 1 0
		£255 19 4

	£ s. d.	£ s. d.
Expended during the year:—		
Premium for 1937/8		10 10 0
Balance:—		
Cash at Bank	8 16 2	
Invested in £230 3½ per cent. Registered War Stock at cost	236 13 2	
		245 9 4
		£255 19 4

LIBRARY FUND ACCOUNT, 31st DECEMBER, 1937.

	£ s. d.	£ s. d.
Balance at the beginning of the year	50 5 6	
Expended during the year		10 9 0
Balance:—		
Cash at Bank		39 16 6
		£50 5 6

NATIONAL ILLUMINATION COMMITTEE FUND, 31st DECEMBER, 1937.

	£ s. d.	£ s. d.
Fund at the beginning of the year		355 5 3
War Stock Interest		10 10 0
Deposit Interest		4 10
Sundry Receipts		2 13 4
		£368 13 5

	£ s. d.	£ s. d.
Expended during the year:—		
Grants to I.C.I. Delegates (Paris)		14 9 7
Balance:—		
Cash at Bank	49 15 4	
Invested in £300 3½ per cent. Registered War Stock at cost	304 8 6	
		354 3 10
		£368 13 5

INTERNATIONAL ILLUMINATION CONGRESS FUND (1931), 31st DECEMBER, 1937.

	£ s. d.	£ s. d.
Fund at the beginning of the year		315 15 0
War Stock Interest		10 10 0
		£326 5 0

	£ s. d.	£ s. d.
Expended during the year:—		
Balance:—		
Cash at Bank	21 16 6	
Invested in £300 3½ per cent. Registered War Stock at cost	304 8 6	
		326 5 0
		£326 5 0

We have examined the above accounts with books and vouchers, and certify same to be correct in accordance therewith, and that the Balance Sheet exhibits a true and correct view of the Society's affairs according to the information and explanations given to us.

Dated this 11th day of March, 1938.

ROBERT J. WARD & CO., *Chartered Accountants*,
10, Serjeant's Inn,
Fleet Street, London, E.C.4.

NOTES ON RECENT MEETINGS AND EVENTS

General Meeting in London.

Following the annual general meeting on May 10, an ordinary general meeting was held in the Lecture Theatre of the Institution of Mechanical Engineers (Storey's Gate, Westminster, S.W.1), the President (Dr. S. English) took the chair.

The minutes of the previous meeting having been taken as read the honorary secretary reported that the names of applicants for membership had been posted for the inspection of members.

The President then reminded members that during recent years it had become the practice of the Society, after the annual meeting, to welcome some guest from abroad, who gave some account of developments in his country. On the present occasion they had, as their lecturer, Mr. E. Uytborck, who was chairman of the committee in Belgium that dealt with technical aspects of the production and distribution of electricity.

Mr. Uytborck then delivered his address which consisted in part in a general statistical survey of lighting conditions in Belgium and in part of a description, illustrated by lantern slides, of certain lighting installations in Brussels and Antwerp, including prominent buildings and important arterial roads.

In proposing a very cordial vote of thanks to Mr. Uytborck, which was carried with acclamation, the President commented on certain points of special interest in the paper, making a few inquiries, to which Mr. Uytborck briefly replied.

Sectional Meetings.

Photometry Section.—At a meeting held at the Westminster Technical Institute on Tuesday, April 5, a paper on "Telephotometry" was read by Mr. L. J. Collier, who described in detail various types of instruments used for measuring or comparing the intensity of point sources or extended sources at long range, or based on the Maxwellian view principle. Special reference to the utility of such instruments in connection with the study of atmospheric transmission was made. The paper led to a keen discussion which was opened by Col. C. H. Silvester Evans, and in which Dr. Whipple, Mr. S. Harcombe, Mr. J. M. Waldram, Mr. H. J. A. Turner, Dr. W. S. Stiles, and Mr. J. S. Preston took part. Mr. G. T. Winch presided. The meeting concluded with a cordial vote of thanks to Mr. Collier for his paper and to the Westminster Technical Institute for their hospitality.

Decorative Lighting Section.—Two addresses on "Glassware in Relation to Decorative Lighting," by Dr. W. M. Hampton and "The Value of Glass to Artificial Light," by Mr. Oliver P. Bernard, were given at the meeting of the Decorative Lighting Section held in the Lecture Theatre of Holophane, Ltd. (Westminster), on April 29. The former dealt mainly with the technical aspects of the subject, the latter viewed it from the aesthetic standpoint. In the subsequent discussion Mr. A. B. Read, Mr. R. O. Sutherland, Mr. J. Sherwood, Mr. F. C. Smith, and Mr. A. W. Beuttell took part. On the motion of the latter, who presided, a cordial vote of thanks was passed to the authors of the addresses and to Holophane, Ltd., for their hospitality.

Applications for Membership.

At the general meeting of the Society, held on May 10, 1938, the names of the following applicants for membership were presented:—

Elections Pending.

CORPORATE MEMBERS:—

Ames, J. E. .....70, Oakleigh Park Drive, LEIGH-ON-SEA.

Brunt, H. D. .....22, King's Avenue, Bromley, KENT.

Lunn, E. .....Corporation Electricity Department, Market Street, HUDDERSFIELD.

Mainer, O. E. .....276, Chiswick Village, LONDON, W.4.

Staines, A. J. .....26, Heathlands Road, Sutton Coldfield, WARWICKSHIRE.

White, J. E. .....Newcastle and Gateshead Gas Company, 30, Grainger Street, NEWCASTLE-ON-TYNE.

COUNTRY MEMBERS:—

Arrowsmith, A. W. ...87, Lindridge Road, Erdington, BIRMINGHAM.

Brownsdon, J. B. W. ..19, Belle Walk, Moseley, BIRMINGHAM, 13.

Fuller, C. E. .....P.O. Box 1,055, Wellington, NEW ZEALAND.

Holmes, J. G. .....21, Fitzroy Avenue, BIRMINGHAM, 17.

Hudson, N. .....Woodlands, Hopton, Mirfield, YORKS.

Perkins, R. S. .....31, Pitcairn Road, Warley, Smethwick, BIRMINGHAM.

Webb, R. N. .....Stoneleigh, Bramley, LEEDS.

Elections Completed.

At this meeting the names of those announced on April 12, which were published in the issue of the *Transactions* (Vol. III., No. 4, 1938, p. 50), were presented again, and these applicants were formally declared members of the Society.

THE CALCULATION OF LIGHT OUTPUT FROM OPAL FITTINGS

By J. G. HOLMES, B.Sc., D.I.C., F.Inst.P.

(Communicated by Dr. W. M. Hampton, *Member*).

ABSTRACT.—Methods are given for calculating the light output of an enclosed or reflecting fitting. The formulae are derived from Ryde and Cooper's work, and experimental results give satisfactory confirmation. The light output of any specified fitting is shown by a nomogram and the comparison is made between B.S.S.324 and the German Specification DIN.5036.

Introduction.

It is the aim of every illuminating engineer to be able to forecast accurately the performance of a fitting before it is made and to be able to modify the design in order to improve the performance. The light output of an enclosed globe can be altered very considerably by changing the size of the neck or the position of the lamp, as indicated by table 4, on page 7, of B.S.S.324—1934 ([1]). It is common experience also that the canopy or gallery has a considerable effect on the performance, and that the difference between fittings is more often due to the design of the holder than to the properties of the opal glass.

This paper illustrates the method of calculating either the light output to be expected of a fitting or the effect of alteration of some of the component parts. As an example, comparison is made between calculation and measurement of an opal sphere by the method in B.S.S.324 and of an opal hemisphere by the method in the German Specification DIN.5036([2]).

The formulae are derived for opal glass or for opalescent glasses (Opaline, Moonstone, Diffusalyte, etc.), but they have been used successfully with clear and with obscured well-glass fittings.

The paper has been written primarily with a view to applying the method to opal globes or to built-up fittings, but there is no restriction as to the type of fitting provided reasonable precautions are taken.

Formulae.

The basic work for all calculations on opal fittings is included in Ryde and Cooper's papers ([3]). The nomenclature used here is the same as theirs:

Flux output of the bare lamp	1.000
Flux output of a closed spherical globe of opal glass	σ
Diffuse reflection factor of opal glass	ρ'
Diffuse transmission factor	τ'
Angle subtended by the diameter of the neck at the light source	θ
Mean reflection factor of the canopy	r
Flux output of globe mounted in canopy	η_o

Several other symbols may be added to correspond with the German specification, which uses black canopies only:

Flux output of the bare lamp	A_o
Flux output of globe with neck open	B_o
Flux directly incident from the lamp on to the opal globe	D_o
Flux transmitted through the opal...	C_o
Diffuser-transmission	τ_H
Diffuser-absorption	α_H
Diffuser-reflection	ρ_H
Diffuser-efficiency	η_H

The relations between the above symbols can be derived from Ryde and Cooper's papers. The derivations are not given in detail here for reasons of space, but the following equations give the necessary relationships:—

$$\tau' = \sigma\,(1-\rho') \qquad \ldots\ldots(1)$$

$$\tau' = \eta_o\left[r-\rho'+(1-r)\,\sec^2\theta/4\right] \qquad \ldots\ldots(2)$$

$$B_o/A_o = \frac{\sec^2\theta/4-(1-\tau')}{\sec^2\theta/4-\rho'} \qquad \ldots\ldots(3)$$

$$C_o/A_o = \frac{\tau'}{\sec^2\theta/4-\rho'} \qquad \ldots\ldots(4)$$

$$D_o/A_o = \frac{1}{\sec^2\theta/4} \qquad \ldots\ldots(5)$$

The definitions of the German coefficients are as follows for the case when r = 0, i.e., the canopy is dead black:—

$$\tau_H = C_o/D_o = \frac{\tau'\sec^2\theta/4}{\sec^2\theta/4-\rho'} \qquad \ldots\ldots(6)$$

$$\alpha_H = \frac{A_o-B_o}{D_o} = \frac{(1-\tau'-\rho')\sec^2\theta/4}{\sec^2\theta/4-\rho'} \qquad \ldots\ldots(7)$$

$$\rho_H = 1-(\tau_H+\alpha_H) = \frac{B_o+D_o-(A_o+C_o)}{D_o} = \frac{\rho'(\sec^2\theta/4-1)}{\sec^2\theta/4-\rho'} \qquad \ldots\ldots(8)$$

$$\eta_H = 1-\alpha_H = \frac{B_o+D_o-A_o}{D_o} = \frac{(\tau'+\rho')\sec^2\theta/4-\rho'}{\sec^2\theta/4-\rho'} \qquad \ldots(9)$$

The above formulae apply to globes with one or several apertures. The value of θ is chosen to represent the equivalent value of these apertures by the relation:—

$$\cos\theta/2 = 1-\frac{\text{Total solid angle of apertures subtended at the light source}}{2\pi} \qquad \ldots\ldots(10a)$$

or alternatively:

$$\sec^2\theta/4 = \frac{4\pi}{\text{Total solid angle covered by globe}} \qquad \ldots\ldots(10b)$$

Measurements.

It is first of all important to check the formulae stated above.

Complete opal sphere—B.S.S. method with white screens.

A 12-in. sphere with a 4½-in. diameter hole was selected and an opal disc was cut from another similar sphere so as to cover the opening. The following measurements were made:—

1. The sphere was suspended by three thin wires at the centre of an 84-in. integrating cube. A

100-watt uncapped clear wreath-filament lamp was suspended in the centre of the sphere and the opening was closed by the opal disc. The total light output of this assembly was compared with that from the bare lamp, making the necessary corrections for obstructions within the integrator, and the value obtained for the light output ratio of the complete sphere (σ) was 0.908.

2. The opal disc was replaced by an opaque white card of 80% reflection factor and the measurements repeated. The value of the total light output of this assembly relative to that of the bare lamp (η_o) was 0.895. The value of the plane angle subtended by the diameter of the neck at the centre of the light source (θ) was 40°.
3. The average reflection factor of the sphere for parallel incident light (ρ') was obtained without breaking it by comparison with calibrated standards and the value obtained was 0.60.

Opal hemisphere—German method with black screens.

An average hemisphere was cut out of the spherical globe and the aperture closed by an opaque 12-in. disc painted dead black on the inside and white on the outside. Thin wires were used to suspend the assembly in the integrator. The light source was a 60-watt uncapped clear lamp suspended within the bowl so that its filament centre was 2.0 in. inside the aperture. Taking the total flux output of the bare lamp as unity, the following measurements were made:—

A_o Total flux, from naked source..... 1.000
B_o Total flux, less loss in globe 0.953
C_o Total transmitted flux 0.378
D_o Total flux incident on globe 0.651

The value of the angle subtended by the aperture at the source (θ') was 143°.

Calculations.

From the above formulae, the following figures may be writen down from the measurements made on the original spherical globe by the B.S.S. method:—

σ 0.908
θ 40°
r 0.80
ρ' 0.60
η_o 0.895 (measured)

From these the following may be calculated:

r' 0.363.
η_o 0.894 (calculated).

The formulae (1), (2), (3), and (5) may be applied to calculate the measurements described as A_o, B_o, C_o and D_o.

TABLE I.

Measurement	Constants required	Calc'd value	Measured value	Diff.
A_o Total flux	—	1.000	1.000	—
B_o Total flux less that lost in globe	$\theta'=143°$ $\rho'=0.60$ $r'=0.363$	0.960	0.953	0.007
C_o Transmitted flux	$r=0.00$ $\theta'=143°$ $\rho'=0.60$ $r'=0.363$	0.395	0.378	0.017
D_o Flux incident on globe	$\theta'=143°$	0.658	0.651	0.007

From the above figures the values of the transmission, absorption, reflection, and efficiency of the hemispherical bowl can be derived:

TABLE II

	Calculated values	Measured values	Difference
Diffuser-Transmission τ_H	0.600	0.580	0.020
Diffuser-Absorption α_H	0.061	0.072	0.011
Diffuser-Reflection ρ_H	0.339	0.348	0.009
Diffuser-Efficiency η_H	0.939	0.928	0.011

The agreement is good throughout, the largest discrepancy between calculated and measured values occurring in case C_o. This is the case where the aperture in the globe is closed by a black screen and where a small difference in the position of the lamp may cause an appreciable difference in the light output. Since the lamp used was not a point source, exact agreement would not be expected for this case.

The above calculations show that the formulae derived by Ryde and Cooper are applicable to the extreme case of black canopies within the limits of experimental error. This implies that accurate calculation can be made of the efficiency and properties of a fitting without the necessity of measurement. It is also obvious, for instance, that the merits of the German or other proposals may be determined better by calculation than by the measurement of a variety of assemblies.

Application of the Formulae.

The calculation of the hemispherical globe was an example of the method to be generally adopted. The first step is to find the equivalent angle for the neck (θ) by equation (10), which may be rather difficult for some types of built-up fitting but is never worse than simple solid geometry.

The properties of the opal glass are not liable to a great variation, and Table III. gives certain figures which hold for the majority of glasses from reputable manufacturers.

As regards the effect of the thickness of the opal on the transmission and reflection factors, reference to Example (2) on page 39 of the "Illuminating Engineer" for February, 1933, will show the method to be used. This involves the fundamental constants

NB and μ but the conversion is quite simple, and no further example need be given.

The effective reflection factor of the canopy is of prime importance. Tables of reflection factors are given by Moon ([4]) and by Luckiesh and Moss ([5]). An

TABLE III.

	Transmission factor τ'	Reflection factor ρ'	Transmission of spherical globe σ
Flashed opal sheet	0.35—0.6	0.35—0.6	0.85—0.93
3-ply opal globes	0.35—0.5	0.45—0.6	0.88—0.95
Blown solid opal for electric fittings	0.35—0.55	0.4 —0.6	0.82—0.92
Chance's 'Resistopal'	0.35—0.65	0.35—0.6	0.85—0.90
Pot opal sheet (for reflection)	0.05—0.20	0.7 —0.9	—

Flashed opal on a coloured base (sheet and globes) :—

	Transmission factor τ'	Reflection factor ρ'		Transmission (Opal inside)
		Opal Side	Coloured Side	
Pink	0.4 —0.5	0.4—0.5	0.35—0.45	0.70—0.80
Amber	0.4 —0.5	0.4—0.5	0.35—0.45	0.65—0.75
Yellow	0.45—0.55	0.4—0.5	0.4 —0.5	0.70—0.80
Green	0.35—0.45	0.4—0.5	0.3 —0.4	0.60—0.70
Light blue	0.45—0.55	0.4—0.5	0.4 —0.5	0.70—0.80
Dark blue	0.25—0.3	0.4—0.5	0.2 —0.3	0.30—0.40

excellent summary of the data for reflection factors is contained in the booklet " Scientific Industrial Illumination," issued by Messrs. Holophane, Ltd. The method of calculating the effective reflection factor of a deep canopy is given by Higbie ([6]), who also quotes several examples of the type discussed in this paper.

Having decided on the figures for the properties of the opal and of the canopy, it is only necessary to insert them in equation (2) and solve for the light output ratio of the assembled fitting (η_o). This may be done arithmetically, but a rapid and sufficiently accurate method is to use the nomogram shown as Fig. 1. A straight line should be drawn through the appropriate values of ρ' and r intersecting the reference line at some point R. A second straight line is then drawn joining R to the appropriate value of θ and the intersection on the η_o/σ scale gives the efficiency of the fitting. This figure should be multiplied by σ in order to give the actual light output relative to that of the unscreened lamp. The lines drawn in Fig. 1 represent the calculation for the 12″ hemisphere with a black canopy (r = 0) and give an efficiency of 0.435, which, when multiplied by $\sigma = 0.908$, gives a light output ratio of 0.395, as calculated above. This nomogram has given results quite as accurate as the experimental measurements for several experiments in which r and ρ' or r and θ have been varied together, and it provided a very easy check on the use of different methods. The same experiments, which included semi-cube and semi-

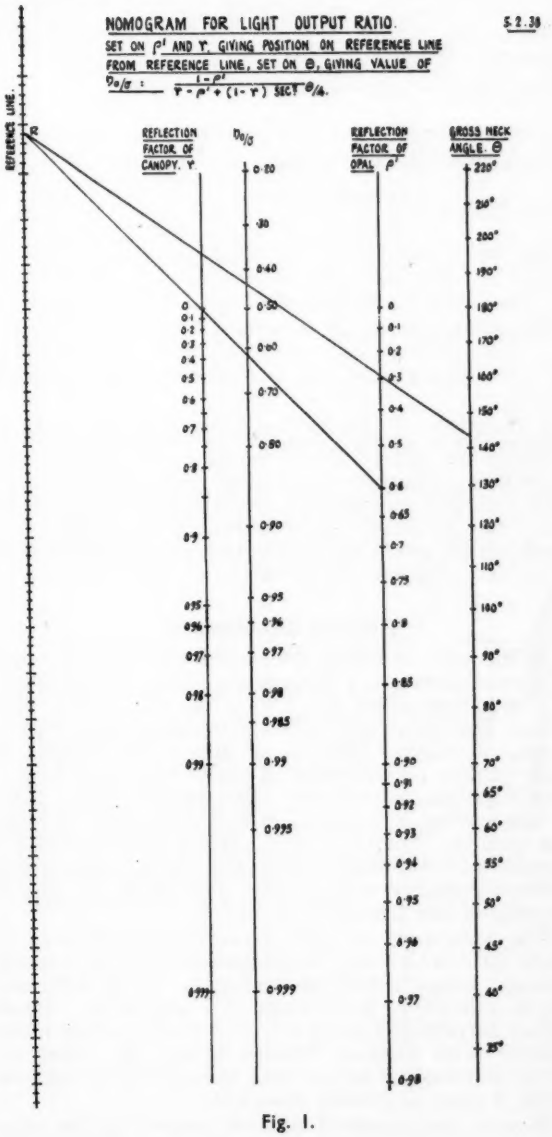
NOMOGRAM FOR LIGHT OUTPUT RATIO.
5.2.38
SET ON ρ' AND Y, GIVING POSITION ON REFERENCE LINE
FROM REFERENCE LINE, SET ON θ, GIVING VALUE OF
η₀/σ :
REFERENCE LINE
REFLECTION FACTOR OF CANOPY. Y
η₀/σ
REFLECTION FACTOR OF OPAL ρ'
GROSS NECK ANGLE. θ

Fig. 1.

cylindrical shaped globes, indicated that equation (2) holds exactly for simple shapes. It has not been tested for re-entrant or complex shapes, but there is no reason to suppose that serious discrepancies might occur.

The calculation of the efficiency of a reflecting bowl may be made by the use of equation (3), which gives the total flux leaving an opal globe with an unobstructed aperture.

A common form of globe is the cup-shaped reflector, which has a narrow neck closed by the gallery and a wide mouth. This may be treated by using equation (3) for the case when both apertures are open to give the total light output, and then using

TABLE IV.

Properties of opal		Good opal glasses.		Bad opal glasses.	
	ρ'	0.60	0.30	0.51	0.57
	τ'	0.37	0.63	0.40	0.35
	σ	0.925	0.900	0.815	0.815
Percentage efficiency of glass...		92.5%	90.0%	81.5%	81.5%

Assembly of fitting		Light output ratios and percentage efficiency of canopy.							
		η_o	Effic.	η_o	Effic.	η_o	Effic.	η_o	Effic.
θ= 90°	White paint r = 0.80	0.85	92 %	0.86	95.5%	0.76	93 %	0.755	92.5%
	Grey paint r = 0.30	0.71	77 %	0.76	84.5%	0.65	79.5%	0.635	78 %
	Black paint r = 0.05	0.66	71.5%	0.73	82 %	0.605	74 %	0.59	72.5%
θ=140°	White paint r = 0.80	0.745	80.5%	0.785	87 %	0.675	82.5%	0.66	81 %
	Grey paint r = 0.30	0.495	53.5%	0.60	69 %	0.48	59 %	0.455	56 %
	Black paint r = 0.05	0.445	48 %	0.54	60 %	0.415	51 %	0.395	48.5%

equation (4) to give the light actually transmitted through the glass. The difference will be the total light flux passing through the two openings, and from this the light flux passing through the mouth of the bowl may be estimated. This should be added to that transmitted by the opal glass to give the light output ratio of the assembled fitting.

General Conclusions.

In the introduction it was stated that the efficiency of an enclosed fitting is controlled more by the design of the canopy than by the properties of the opal globe. The following figures illustrate several typical cases. The two "good" opal glasses are typical of high quality manufacture of white opal and of opalescent globes respectively. The second "good" glass is also similar to a deeply etched clear glass of average quality. The two "bad" opal glasses would not comply with B.S.S.324—1934, the first because of low reflecting ability—i.e., a grey glass—and the second because of low transmitting ability.

The worst opal in general use has an efficiency of about 80%, which may be compared with the average canopy, whose reflection factor is about 0.30 and whose efficiency is between 55% and 80%. These rather surprising figures are even more serious when dealing with built-up fittings where the reflecting surfaces are often larger than the opal itself and the angle θ may be greater than 180°.

Several points are of interest regarding the technique of measurement of opal globes. It has been stated that black screens are more critical than white as regards the exact position of the light source. It may be shown from the formulae above that the variation of the light output ratio of the assembly of globe and screens (denoted by η_o or C_o) with small displacements of the light source, is proportional to the absorption of the screens (1-r). In this respect, therefore, errors in the German method would appear to be five times as serious as in the B.S.S. method. The exact relation is:

$$\frac{d\eta_o}{d\theta} = -\frac{\eta_o^2}{2r'}(1-r)\sec^2\theta/4.\ \tan\theta/4 \quad \ldots\ldots\ldots\ldots(11)$$

The effect of small changes in the reflection factor of the screens (r) should be considered. It is generally accepted that black screens can be maintained more easily than grey or white, and this is emphasised by the fact that the least perceptible change in reflection factor is proportional to r, so that slight departures from blackness are much more noticeable than small departures from, say, r = 0.80. By differentiation of equation (2) we obtain:

$$\frac{d(\eta_o/\sigma)}{dr} = \frac{(1-\rho')(\sec^2\theta/4-1)}{[(1-\rho')+(1-r)(\sec^2\theta/4-1)]^2} \quad \ldots\ldots\ldots\ldots(12)$$

This is a minimum for r = 0 and maximum at r = 1. Taking the least perceptible increment of r to be dr/r, the relation becomes:

$$\frac{d(\eta_o/\sigma)}{dr/r} = \frac{r(1-\rho')(\sec^2\theta/4-1)}{[(1-\rho')+(1-r)(\sec^2\theta/4-1)]^2} \quad \ldots\ldots\ldots\ldots(13)$$

The values for the right-hand side of the cases considered above are:

TABLE V.

Spherical globe:	r=0.80	r=0.05
$\frac{d(\eta_o/\sigma)}{dr}$	0.0305	0.0288
$\frac{d(\eta_o/\sigma)}{dr/r}$	0.0244	0.0014
Hemispherical globe:		
$\frac{d(\eta_o/\sigma)}{dr}$	0.412	0.232
$\frac{d(\eta_o/\sigma)}{dr/r}$	0.329	0.012

Thus the variation of the light output of the assembly of globe and screens with small errors in the reflection factor of the screens is greater by the B.S.S. method than by the German method. This is not of material importance for two reasons: firstly, that the accurate measurements with the white screen and uncapped lamp assembly are only made very occasionally in order to provide working standards, and therefore deterioration of the screens does not matter. Secondly, the B.S.S. only defines limiting values of the reflection factor (r) and of the light output ratio (η_o), and the specification is not invali-

dated so long as these constants are within these values. It is certain, however, that accurate measurement of the reflection factor (r) is necessary for exact use of the B.S.S. method in absolute measurements.

It is interesting to note that although the British and German methods of measurement are very different in technique, the two tests are consistent and lead essentially to the same results for the intrinsic properties of the glass. From the user's point of view the relative values of the two tests lie in the comparative usefulness of the quantities obtained rather than in the differences in ease of measurement.

It appears, then, that not only can the performance of a fitting be predicted before it is made, but also that the effect of the individual components of the fitting can be determined. This determination is likely to be as accurate, in the absolute sense, as measurement of a series of fittings, and will be more accurate in the relative sense owing to the elimination of varying experimental error.

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